# Hex Chrome Free Coatings for Electronics

## NASA-DoD-OEM Joint Project

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# Report Documentation Page

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# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Objective

- Evaluate and test hexavalent-chrome free pretreatments for avionics and electronics applications

## Benefits

- Project builds off of previously successful NASA and DoD testing
- Reduced risk for materials obsolescence of hex-chrome coatings with the discovery of coatings that perform to the requirements for current and future Programs within NASA, the DoD and ESA
- Continue to collaborate with DoD and industry to identify and test alternatives for various applications within the aerospace community

If a qualified technology or product is implemented, it will:

- Meet environmental and safety regulatory requirements
- Reduce need to monitor for chromium exposure due to new regulations
- Decrease risk of environmental, worker and public exposure
- Reduce maintenance cost and government liability

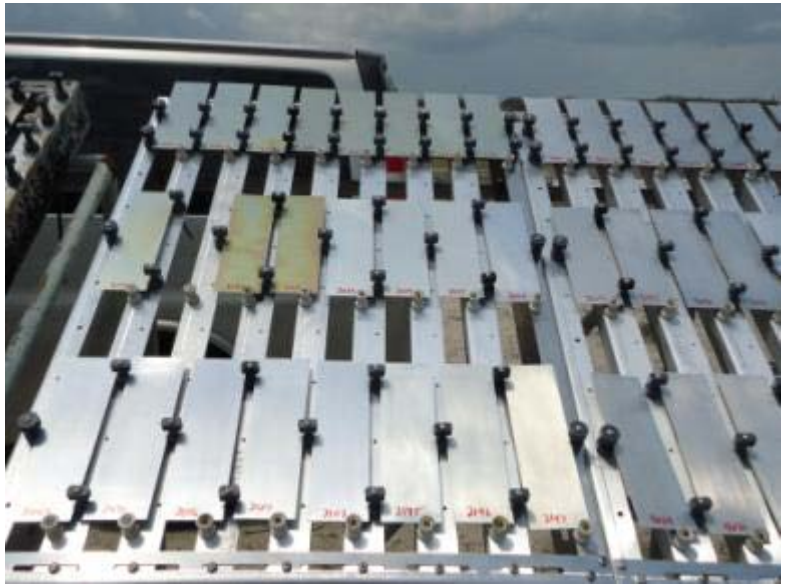
# Hex Chrome Free Coatings for Electronics (NASA-DoD)

**Pretreatments**

- Alodine 1600 (Control)
- Metalast HF
- Metalast HFEPA
- SurTec 650
- SurTec 650 C
- Alodine T 5900 RTU
- Iridite NCP

**Substrates**

- 6061-T6
- 7075-T73
- 2024-T3
- 5052-H32



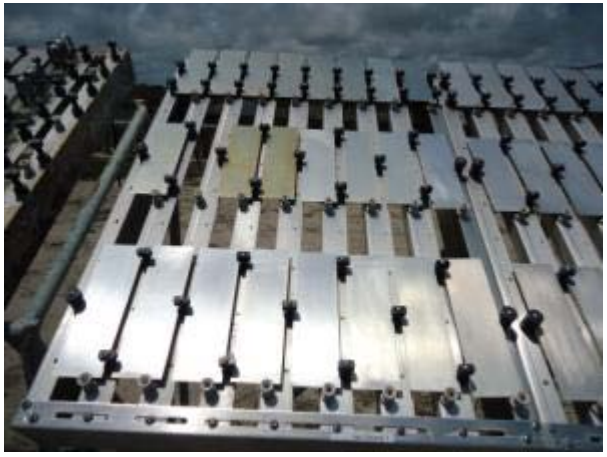
**Limited Screening Tests**

- Alodine EC2
- Corrlink 30A
- Deft RECC
- UMR CeCC
- EonCoat
- PPG X-Bond 4000
- Metalast TCPCC-600P
- NANOMYTE PT-10
- NANOMYTE TC-4001
- Alodine 160/161
- Alodine 5923 Plus
- Interlox 5705

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

**Testing** {NASA KSC Corrosion Technology Lab and Beachside Corrosion Lab}

- Salt Spray Resistance
  - ASTM B 117
    - 168 hours
    - To failure
  - Surface Resistance (ASTM D 257)
  - Contact Electrical Resistance (81706)
- Cyclic Corrosion
  - ASTM G 85, Annex 5
- 18-Month Marine Environment
  - KSC Beach Corrosion Test
- Patti-Jr. Pull-Off Adhesion Test
  - ASTM D 4541
- Cross-Cut Tape Test
  - ASTM D 3359, Procedure B
- Wet Tape Paint Adhesion
  - 24 Hour Immersion
  - 96 Hour Immersion at 120$^{o}$F



# Hex Chrome Free Coatings for Electronics (NASA-DoD)

**Panel Preparation** {NASA KSC Corrosion Technology Lab}

- The panel preparation procedure was developed as part of the NASA TEERM Hexavalent Chrome Alternatives for Aerospace Project. Stakeholders participating in the Hexavalent Chrome Free Coatings for Electronics Applications Project agreed to the procedure.

1. Solvent Hand Cleaning
   a. Ethanol {200 proof}.
2. Mild Alkaline Aqueous Degreaser (Non-Silicate)
   a. Chemetall-Oakite NST – (5% by volume @ 49º - 54ºC for 4 minutes.)
3. DI water rinse to water break-free. Preceding degreasing steps will be repeated until water break-free is achieved.
4. Deoxidize Bath (Oakite LNC)
   a. Oakite LNC (10% by volume @ ambient temperature for 3 - 4 minutes.)
5. Rinse thoroughly using clean (5 megaohm or better) DI ambient temperature water.
6. Take panels directly to pretreatment bath

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Salt Spray Resistance (ASTM B 117, 168 hours)

| Pretreatment | Alloy | B117 @ 168 Hours |
|---|---|---|
| Control | 6061-T6 | Fail |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Fail |
| Alternative 1 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 2 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 3 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |

| Pretreatment | Alloy | B117 @ 168 Hours |
|---|---|---|
| Alternative 4 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 5 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 6 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |

Alternatives are not listed in the same order as they are listed on Slide 3

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Salt Spray Resistance (ASTM B 117, to failure)

| Pretreatment | Alloy | B117 to Fail |
|---|---|---|
| Control | 6061-T6 | 4 of 5 Pass @ 168 |
| | 7075-T73 | Failed @ 168 |
| | 2024-T3 | Failed @ 168 |
| | 5052-H32 | 1 of 5 Pass @ 168 |
| Alternative 1 | 6061-T6 | 3 of 5 Pass @ 168 |
| | 7075-T73 | Failed @ 168 |
| | 2024-T3 | Failed @ 168 |
| | 5052-H32 | Pass @ 1008 |
| Alternative 2 | 6061-T6 | 4 of 5 Pass @ 168 |
| | 7075-T73 | Failed @ 168 |
| | 2024-T3 | Failed @ 168 |
| | 5052-H32 | 4 of 5 Pass @ 1008 |
| Alternative 3 | 6061-T6 | 1 of 5 Pass @ 168 |
| | 7075-T73 | Failed @ 168 |
| | 2024-T3 | Failed @ 168 |
| | 5052-H32 | 2 of 5 Pass @ 1008 |

| Pretreatment | Alloy | B117 to Fail |
|---|---|---|
| Alternative 4 | 6061-T6 | 4 of 5 Pass @ 168 |
| | 7075-T73 | Failed @ 168 |
| | 2024-T3 | Failed @ 168 |
| | 5052-H32 | Pass @ 1008 |
| Alternative 5 | 6061-T6 | 4 of 5 Pass @ 168 |
| | 7075-T73 | Failed @ 168 |
| | 2024-T3 | Failed @ 168 |
| | 5052-H32 | Pass @ 1008 |
| Alternative 6 | 6061-T6 | 4 of 5 Pass @ 168 |
| | 7075-T73 | Failed @ 168 |
| | 2024-T3 | Failed @ 168 |
| | 5052-H32 | 4 of 5 Pass @ 1008 |

*Note - All five 6061-T6 test panels as well as 1 of 5 test panels for 7075-T73, 2024-T3, and 5052-H32 for all pretreatments were used for ASTM D 257 readings. Test panels were not tested at the same time as the others listed in the table. Testing with these test panels was stopped after 168 hours.

Alternatives are not listed in the same order as they are listed on Slide 3

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Cyclic Corrosion (ASTM G 85, Annex 5, 168 hours)

| Pretreatment | Alloy | G85 @ 168 Hours |
|---|---|---|
| Control | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 1 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 2 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 3 | 6061-T6 | Fail |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Fail |

| Pretreatment | Alloy | G85 @ 168 Hours |
|---|---|---|
| Alternative 4 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 5 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |
| Alternative 6 | 6061-T6 | Pass |
| | 7075-T73 | Fail |
| | 2024-T3 | Fail |
| | 5052-H32 | Pass |

Alternatives are not listed in the same order as they are listed on Slide 3

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Combined Data

| Pretreatment | Alloy | B117 @ 168 Hours | B117 to Fail* | G85 @ 168 Hours |
|---|---|---|---|---|
| Control | 6061-T6 | Fail | 4 of 5 Pass @ 168 | Pass |
| | 7075-T73 | Fail | Failed @ 168 | Fail |
| | 2024-T3 | Fail | Failed @ 168 | Fail |
| | 5052-H32 | Fail | 1 of 5 Pass @ 168 | Pass |
| Alternative 1 | 6061-T6 | Pass | 3 of 5 Pass @ 168 | Pass |
| | 7075-T73 | Fail | Failed @ 168 | Fail |
| | 2024-T3 | Fail | Failed @ 168 | Fail |
| | 5052-H32 | Pass | Pass @ 1008 | Pass |
| Alternative 2 | 6061-T6 | Pass | 4 of 5 Pass @ 168 | Pass |
| | 7075-T73 | Fail | Failed @ 168 | Fail |
| | 2024-T3 | Fail | Failed @ 168 | Fail |
| | 5052-H32 | Pass | 4 of 5 Pass @ 1008 | Pass |
| Alternative 3 | 6061-T6 | Pass | 1 of 5 Pass @ 168 | Fail |
| | 7075-T73 | Fail | Failed @ 168 | Fail |
| | 2024-T3 | Fail | Failed @ 168 | Fail |
| | 5052-H32 | Pass | 2 of 5 Pass @ 1008 | Fail |
| Alternative 4 | 6061-T6 | Pass | 4 of 5 Pass @ 168 | Pass |
| | 7075-T73 | Fail | Failed @ 168 | Fail |
| | 2024-T3 | Fail | Failed @ 168 | Fail |
| | 5052-H32 | Pass | Pass @ 1008 | Pass |
| Alternative 5 | 6061-T6 | Pass | 4 of 5 Pass @ 168 | Pass |
| | 7075-T73 | Fail | Failed @ 168 | Fail |
| | 2024-T3 | Fail | Failed @ 168 | Fail |
| | 5052-H32 | Pass | Pass @ 1008 | Pass |
| Alternative 6 | 6061-T6 | Pass | 4 of 5 Pass @ 168 | Pass |
| | 7075-T73 | Fail | Failed @ 168 | Fail |
| | 2024-T3 | Fail | Failed @ 168 | Fail |
| | 5052-H32 | Pass | 4 of 5 Pass @ 1008 | Pass |

Alternatives are not listed in the same order as they are listed on Slide 3

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Cross-Cut Tape Test (ASTM D 3359, Procedure B)

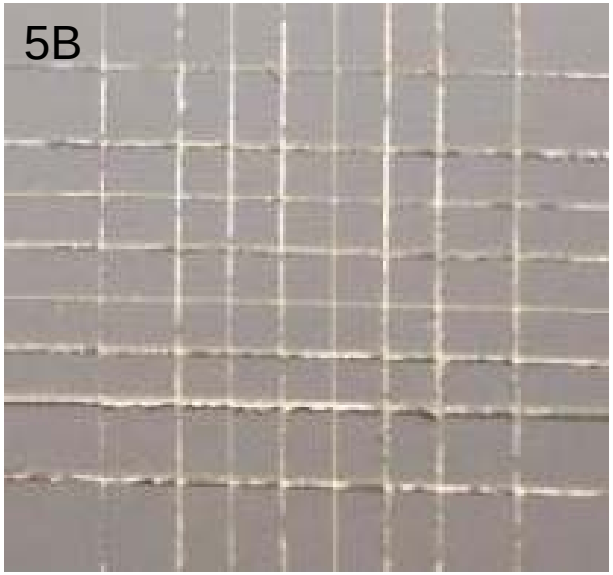
**Primer (MIL-PRF-23377) - PPG CA7233**

| Pretreatment | Alloy | Result |
|---|---|---|
| Alternative 1 | 6061-T6 | 1B |
| | | 1B |
| | 5052-H32 | 1B |
| | | 1B |
| Alternative 2 | 6061-T6 | 5B |
| | | 2B |
| | 5052-H32 | 4B |
| | | 5B |
| Alternative 3 | 6061-T6 | 5B |
| | | 5B |
| | 5052-H32 | 5B |
| | | 5B |
| Alternative 4 | 6061-T6 | 1B |
| | | 1B |
| | 5052-H32 | 1B |
| | | 1B |
| Alternative 5 | 6061-T6 | 2B |
| | | 1B |
| | 5052-H32 | 1B |
| | | 1B |
| Alternative 6 | 6061-T6 | 2B |
| | | 2B |
| | 5052-H32 | 2B |
| | | 2B |

**Primer (MIL-PRF-85582) - Deft 44-GN-07A**

| Pretreatment | Alloy | Result |
|---|---|---|
| Alternative 1 | 6061-T6 | 5B |
| | | 5B |
| | 5052-H32 | 5B |
| | | 5B |
| Alternative 2 | 6061-T6 | 5B |
| | | 5B |
| | 5052-H32 | 5B |
| | | 5B |
| Alternative 3 | 6061-T6 | 5B |
| | | 5B |
| | 5052-H32 | 5B |
| | | 5B |
| Alternative 4 | 6061-T6 | 5B |
| | | 5B |
| | 5052-H32 | 5B |
| | | 5B |
| Alternative 5 | 6061-T6 | 5B |
| | | 5B |
| | 5052-H32 | 4B |
| | | 5B |
| Alternative 6 | 6061-T6 | 5B |
| | | 5B |
| | 5052-H32 | 5B |
| | | 5B |

5B = 0% area removed
4B = less than 5% removed
3B = 5 – 15% removed
2B = 15 – 35% removed
1B = 35 – 65 % removed
0B = greater than 65%



# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Wet Tape Paint Adhesion (24 hour immersion, ambient temp)

**Primer (MIL-PRF-23377) - PPG CA7233**

| Pretreatment | Alloy | Result |
|---|---|---|
| Alternative 1 | 6061-T6 | 3A |
| | 5052-H32 | 5A |
| Alternative 2 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 3 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 4 | 6061-T6 | 3A |
| | 5052-H32 | 3A |
| Alternative 5 | 6061-T6 | 5A |
| | 5052-H32 | 4A |
| Alternative 6 | 6061-T6 | 4A |
| | 5052-H32 | 4A |

**Primer (MIL-PRF-85582) - Deft 44-GN-07A**

| Pretreatment | Alloy | Result |
|---|---|---|
| Alternative 1 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 2 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 3 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 4 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 5 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 6 | 6061-T6 | 5A |
| | 5052-H32 | 5A |

- 5A = No peeling or removal
- 4A = Trace peeling or removal along incisions or at their intersection
- 3A = Jagged removal along incisions up to 1.6 mm (1⁄16 in.) on either side
- 2A = Jagged removal along most of incisions up to 3.2 mm (1⁄8 in.) on either side
- 1A = Removal from most of the area of the X under the tape
- 0A = Removal beyond the area of the X

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Wet Tape Paint Adhesion (96 Hour Immersion at 120°F)

**Primer (MIL-PRF-23377) - PPG CA7233**

| Pretreatment | Alloy | Result |
|---|---|---|
| Alternative 1 | 6061-T6 | 3A |
| | 5052-H32 | 3A |
| Alternative 2 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 3 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 4 | 6061-T6 | 3A |
| | 5052-H32 | 3A |
| Alternative 5 | 6061-T6 | 5A |
| | 5052-H32 | 3A |
| Alternative 6 | 6061-T6 | 3A |
| | 5052-H32 | 3A |

**Primer (MIL-PRF-85582) - Deft 44-GN-07A**

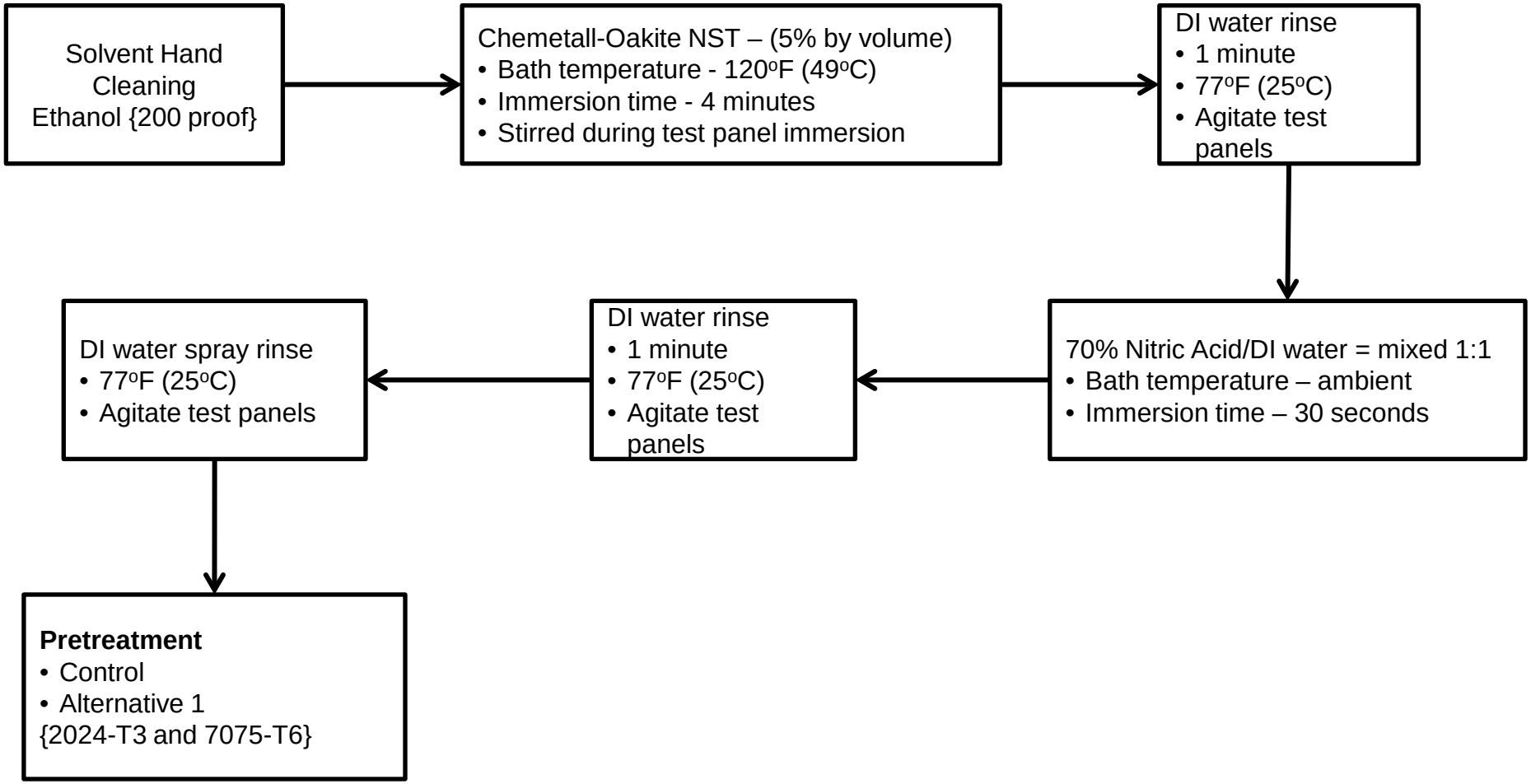
| Pretreatment | Alloy | Result |
|---|---|---|
| Alternative 1 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 2 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 3 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 4 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 5 | 6061-T6 | 5A |
| | 5052-H32 | 5A |
| Alternative 6 | 6061-T6 | 5A |
| | 5052-H32 | 5A |

- 5A = No peeling or removal
- 4A = Trace peeling or removal along incisions or at their intersection
- 3A = Jagged removal along incisions up to 1.6 mm (1⁄16 in.) on either side
- 2A = Jagged removal along most of incisions up to 3.2 mm (1⁄8 in.) on either side
- 1A = Removal from most of the area of the X under the tape
- 0A = Removal beyond the area of the X

# Modified Panel Preparation Procedure

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

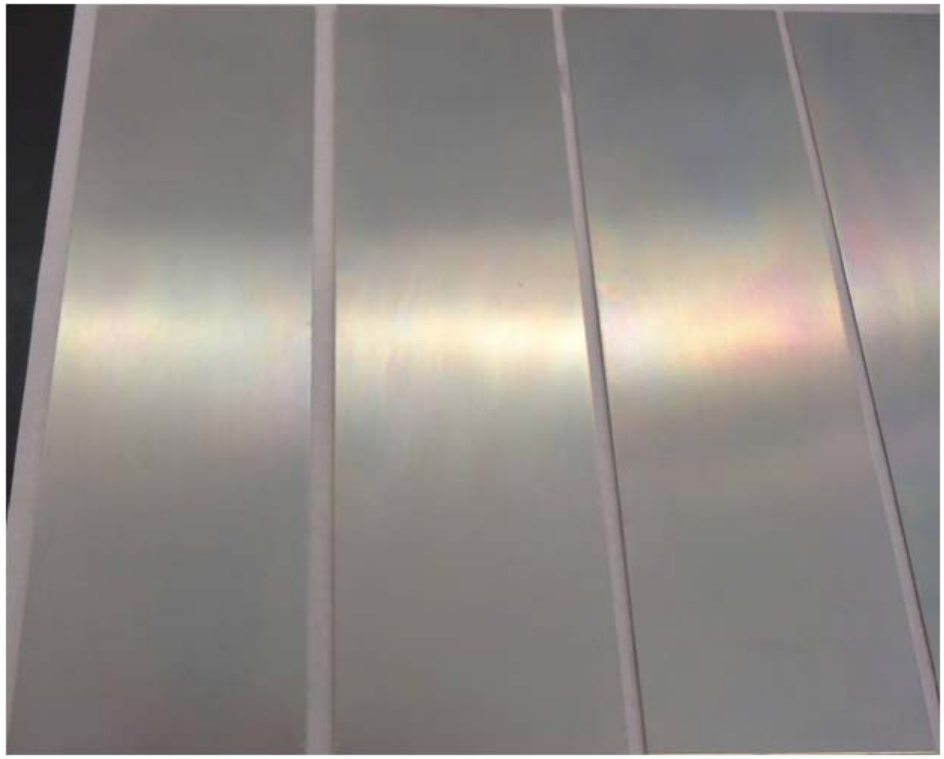
## Modified Panel Preparation Procedure



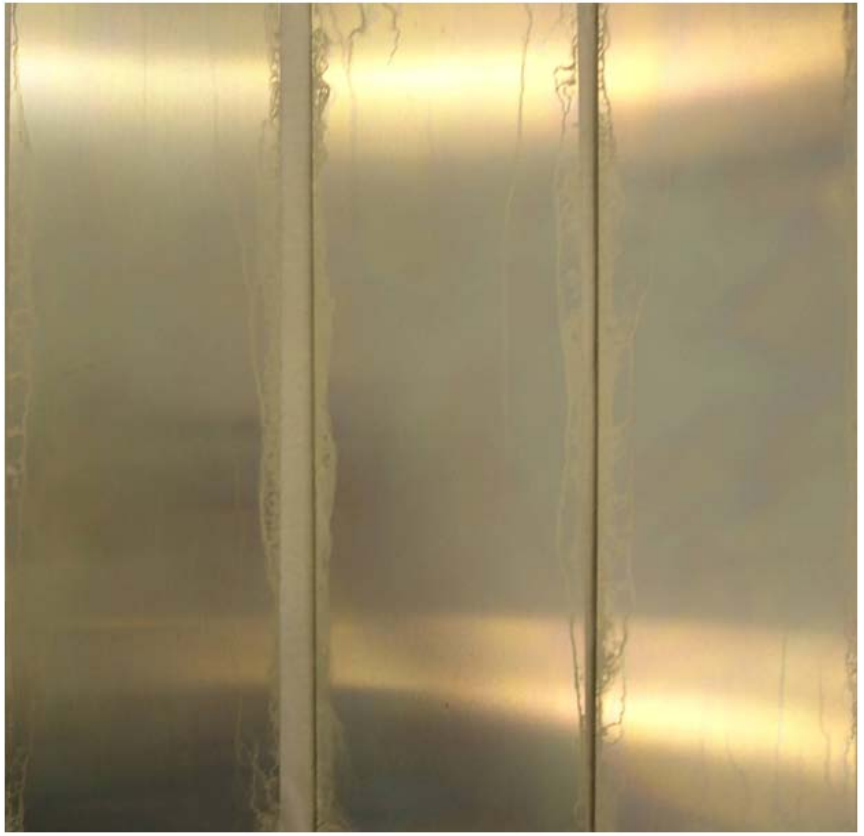
# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## ASTM B 117 Testing

- Control performed very well on the 2024-T3 and 7075-T6 test panels through 336 hours of testing



Control – 2024-T3 – 336 hours ASTM B 117

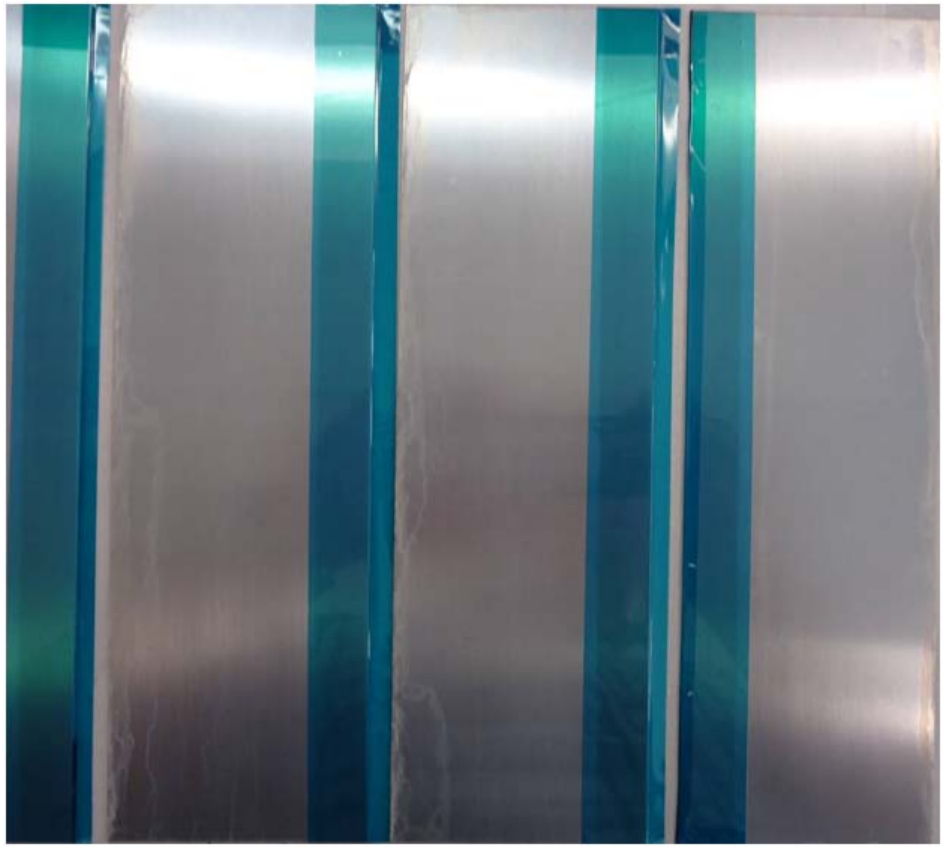


Control – 7075-T6 – 336 hours ASTM B 117

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## ASTM B 117 Testing

- Alternative 1 performed well on the 7075-T6 test panels through 336 hours of testing.
- Alternative 1 did not perform well on the 2024-T3 test panels following 168 hours of testing and were removed from test chamber.



Alternative 1 – 7075-T6 – 336 hours ASTM B 117

Alternative 1 – 2024-T3 – 168 hours ASTM B 117

# Next Phase of Testing

# Hex Chrome Free Coatings for Electronics (NASA-DoD)

**Next Phase -** Two panel prep procedures per pretreatment

**Pretreatments**

- Alodine 1600
- Metalast HF
- SurTec 650
- Iridite NCP

**Substrates**

- 2024-T3 (136)
- 7075-T6 (136)
- 6061-T6 (80)

**Primary Test Panel Count {2024 / 7075}**

- 17 panels per alloy
- 2 alloys
- 4 pretreatments
- 2 processes

272 panels

**Limited Test Panel Count {6061}**

- 10 panels per alloy
- 1 alloys
- 4 pretreatments
- 2 processes

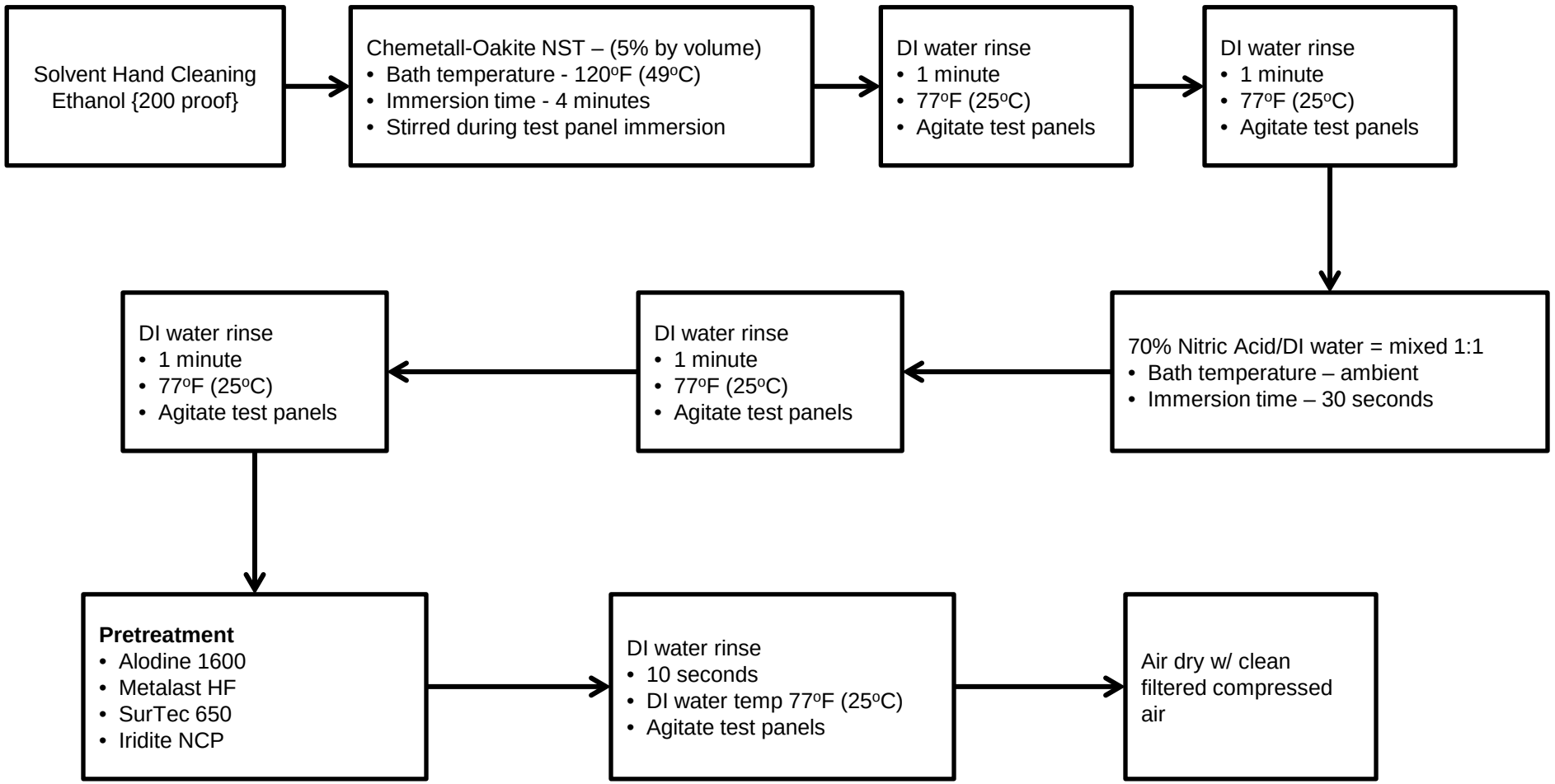
80 panels

**Vendor Applied Pretreatments {2024 / 7075}**

- METALAST TCP-HF / HPA 100
- Deft RECC
- NANOMYTE

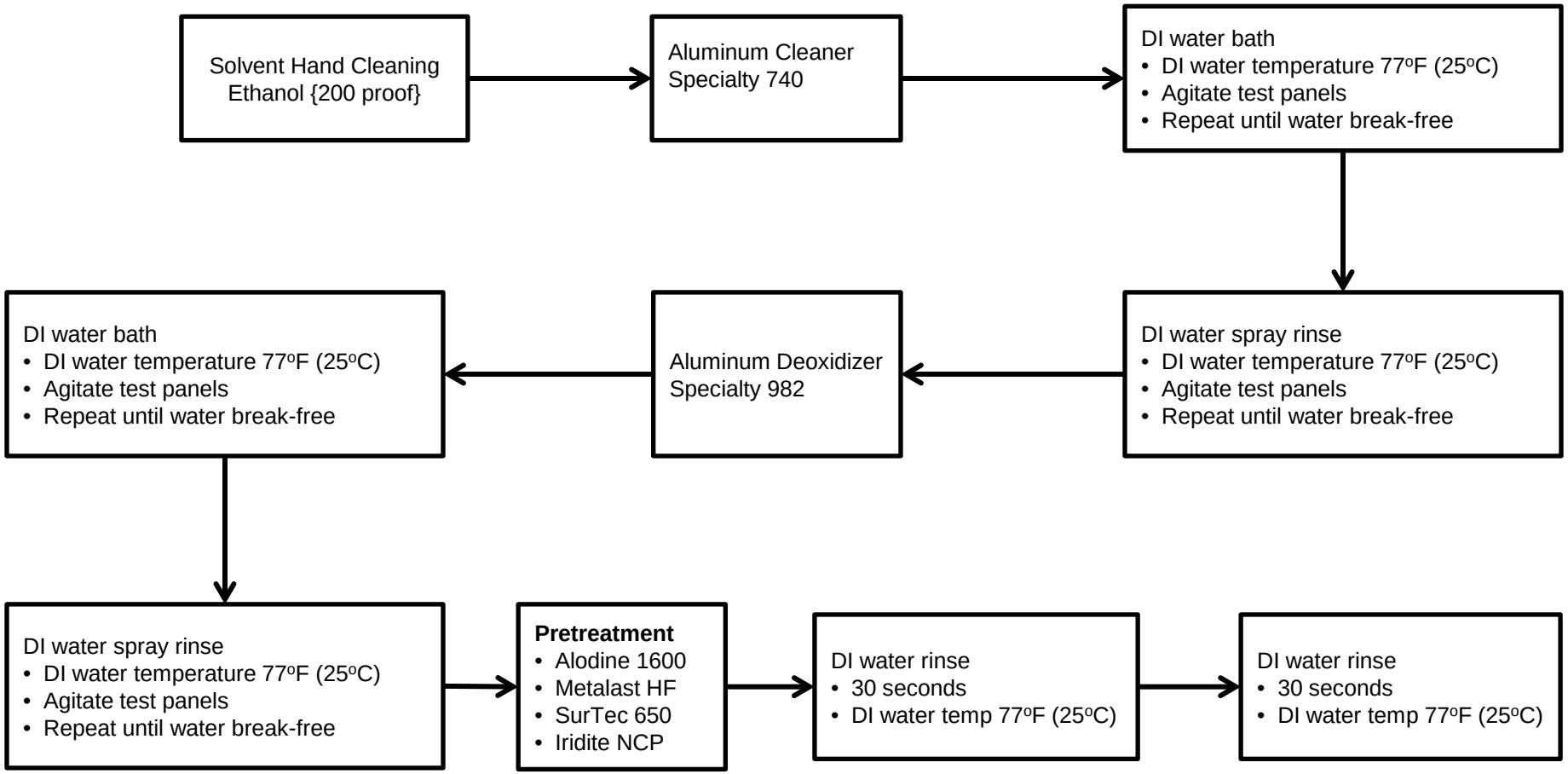
# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## **Next Phase –** Process 1



# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## **Next Phase –** Process 2



# Hex Chrome Free Coatings for Electronics (NASA-DoD)

## Next Phase

### Testing – Primary {2024 / 7075}

- Salt Spray Resistance (5 test panels)
  - ASTM B 117 - To failure with 168 hour inspections
- Cyclic Corrosion (5 test panels)
  - ASTM G 85, Annex 5 – To failure with 168 hour inspections
- Marine Environment (5 test panels)
  - KSC Beach Corrosion Test - To failure with 168 hour inspections
- Wet Tape Paint Adhesion (2 test panels {3x5} per test procedure; 1 for each primer)
  - 24 Hour Immersion
  - 96 Hour Immersion at 120$^{o}$F

### Testing – Limited {6061}

- Salt Spray Resistance (5 test panels)
  - ASTM B 117 - To failure with 168 hour inspections
  - Electrical contact resistance after salt spray exposure
- Electrical Contact Resistance Without Salt Spray Exposure (5 test panels)

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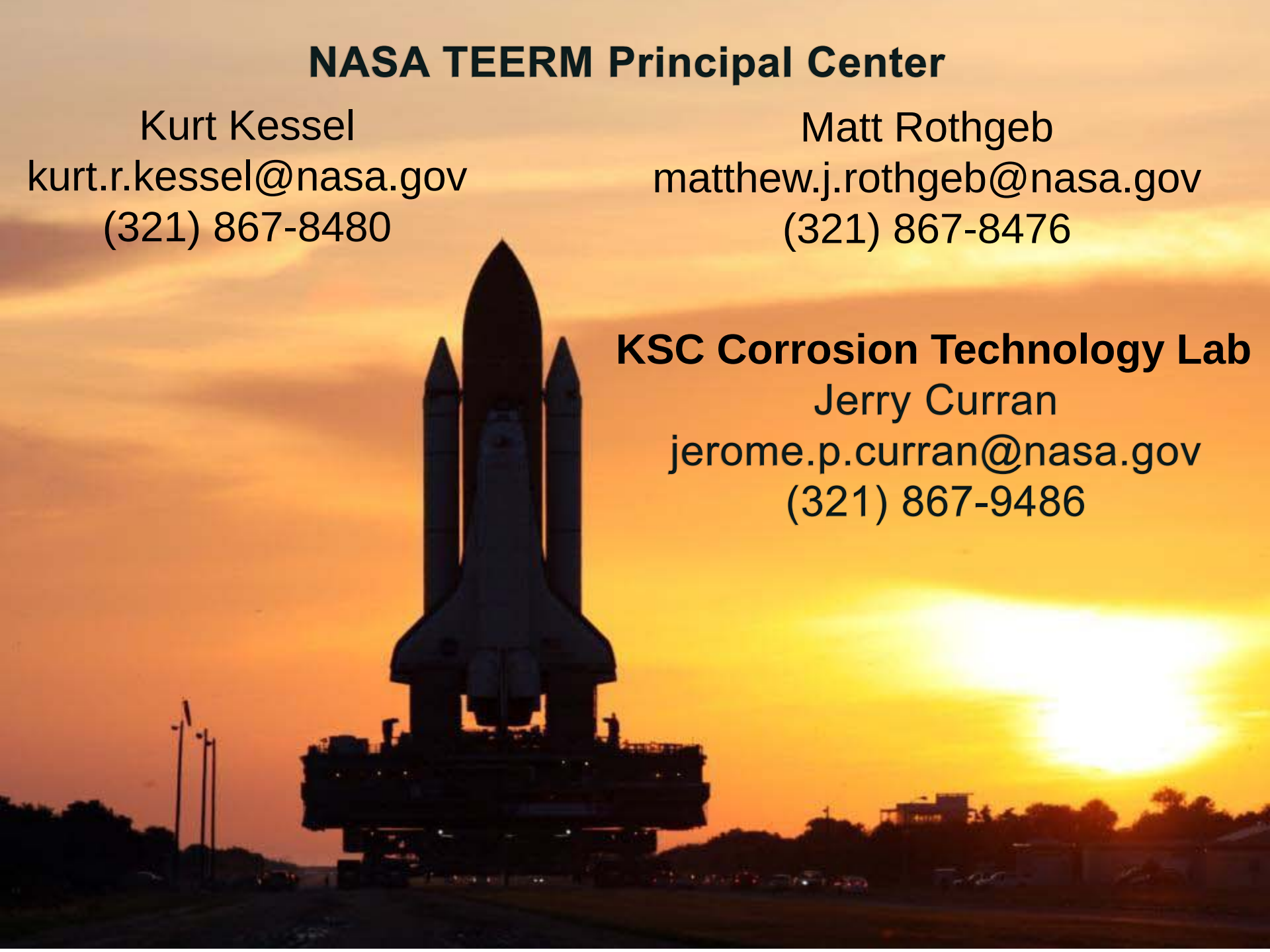

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# Questions?